WATER QUALITY

Project title:	**Survey of High-Altitude Lake Chemistry in National Parks in the Western United States**
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Objective: The objective of this study was to conduct a survey of the chemistry of alpine/subalpine lakes in seven national parks in the western United States. The chemistry of these lakes will give an indication as to their sensitivity to perturbations such as acidic deposition and climate change. Results will be compared to a previous lake chemistry survey done in 1985 to see if there have been significant changes in water quality since the mid-1980s.

Findings: A chemical survey of 72 high-altitude lakes in seven national parks in the western United States was conducted during the fall of 1999. Lakes in the three California parks (Sequoia/Kings Canyon, Yosemite, and Lassen Volcanic) and in Rocky Mountain National Park (Colorado) were dilute; median specific conductances were less than 12 μS/cm and median alkalinities were less than 75 μeq/L. Specific conductances and alkalinities generally were substantially higher in Grand Teton and Yellowstone National Parks (Wyoming), and Glacier National Park (Montana), probably due to the prevalence of more reactive bedrock types. Concentrations of base cations and alkalinity were lowest in lakes in the alpine zone, probably because of minimal vegetation and soil development, and because of fast hydrologic flow rates. These conditions make alpine lakes highly sensitive to atmospheric deposition of pollutants.

Project title: **Reference Stream Monitoring - Long Term Trend Sites**

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Objective: The Department of Environmental Quality, Water Quality Division (DEQ/WQD), has been collecting long-term monitoring data for water quality, macroinvertebrate, and habitat at least impacted, reference stream sites in Yellowstone National Park. This data, along with other reference stream data collected throughout the state, will be used to help assess the quality of water at other sites that have been designated as impaired by the state of Wyoming. The state of Wyoming has been conducting its Beneficial Use Reconnaissance Program on streams that have been listed as impaired, but have been lacking in credible data to support the impairment. The water quality, macroinvertebrate, and habitat data that are collected at these sites will be compared to representative reference stream sites in the state to help judge the impairment.

Findings: Ongoing monitoring of long-term reference site, with no final report available at this time.

Project title: **Trophic Classification of Selected Lakes in Yellowstone National Park**

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Objective: Evaluate the trophic state of five lakes in the southern part of Yellowstone Park by analyzing nutrient concentrations and using traditional trophic models.

Findings: The purpose of this study is to evaluate the trophic state of five lakes in southern Yellowstone National Park in order to determine if the human activity in the local area is having a negative environmental impact and possibly increasing the eutrophication rate. While some previous analyses have been done on these lakes, this study is intended to be a preliminary trophic state evaluation to which future analyses can be compared. The five lakes sampled are Shoshone Lake, Lewis Lake, Heart Lake, Riddle Lake, and Duck Lake. Each lake, with the exceptions of Riddle Lake and Duck

Lake, was sampled at several locations. These samples were taken during the months of June through August of 1999 by Woodruff Miller and Dave Anderson of the BYU Civil & Environmental Engineering Department. The Carlson Trophic State Index, the Vollenweider Model, and the Larsen-Mercier Model were used to determine the trophic state of the lakes at each sampling location. The laboratory results were plotted on the applicable model. The Carlson Model requires measurements of the total phosphorus concentration, total chlorophyll-a concentration, and transparency. The Vollenweider Model requires the total inflowing phosphorus concentration and the hydraulic residence time. Finally, the Larsen-Mercier Model utilizes the mean inflowing phosphorus concentration and a phosphorus retention coefficient. As would be expected, the trophic state of the lakes varied from month to month. Generally, the lakes bordered between the oligotrophic and mesotrophic states. Shoshone Lake is classified as slightly oligotrophic, while Lewis Lake and Heart Lake are classified as slightly mesotrophic. Riddle Lake is classified as mesotrophic and Duck Lake borders on the slightly oligotrophic and slightly mesotrophic state classification. The results are summarized below.

Shoshone Lake Area:
DeLacy Creek (northeast side) - mesotrophic
Shoshone Creek (west side) - slightly oligotrophic
Near outlet (southeast side) - border of oligotrophic & mesotrophic
Shoshone Lake average - slightly oligotrophic
Lewis Lake Area:
Dogshead Creek (northeast side) - mesotrophic
Lewis River (middle north side) - slightly mesotrophic
Boat dock near outlet (south side) - border of oligotrophic & mesotrophic
Lewis Lake average - slightly mesotrophic
Heart Lake Area:
Witch Creek (northwest side) - slightly oligotrophic
Witch Creek (southwest side) - slightly mesotrophic
Heart Lake Average - slightly mesotrophic
Riddle Lake:
North side - mesotrophic
Duck Lake:
East side - border of oligotrophic & mesotrophic

Nitrogen was also measured in the samples so as to determine the nitrogen-phosphorus ratio (N:P ratio) in the lakes. This was done to determine if nitrogen or phosphorus was the limiting nutrient in algal growth. Every sample from all five lakes is phosphorus-limited except the August sample of Shoshone Lake at DeLacy Creek (northeast side) and the July sample of Lewis Lake at Lewis River (middle north side). This trophic state evaluation is meant to be a preliminary study to which future studies can be compared. Further sampling of the lakes and tributaries at different times and different locations will be necessary in the future. Complete 40-page reports of these trophic state classifications have been sent to the Yellowstone Center for Resources at Mammoth and to the Snake Ranger District at the South Entrance.

Project title: **Missouri Madison Water Quality Monitoring Program**

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Objective: Objectives of the biomonitoring pilot study were to: 1) establish baseline conditions; 2) evaluate selected parameters, sampling locations, field and laboratory methods; and 3) evaluate the program's performance with regard to meeting long-term monitoring objectives.

Findings: Macroinvertebrates were collected using the modified kick-net procedure. The samples and data analysis were contracted to McGuire Consulting. The Madison River location in Yellowstone National Park had an increase of abundance of *Potamopyrgus antipodarum*. *Potamopyrgus*, an introduced snail first detected in the Madison River during 1994, accounted for slightly more than 60% of the benthic fauna in 1997 and 1998. Mayflies, stoneflies, and caddisflies are typically the most abundant macroinvertebrates in cobble-bottomed streams with good water quality. Mean values were much lower (less than 40%) at YNP. Lower and/or declining relative abundances of these groups are indicative of increased environmental stress. The YNP site supported a macroinvertebrate assemblage unlike those at any other station.

Project title: **Yellowstone River Basin; National Water Quality Assessment**

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Objective: The overall goals of the NAWQA program are to 1) describe current water-quality conditions for a large part of the nation's freshwater streams and aquifers; 2) describe how water quality is changing over time; and 3) improve our understanding of the primary natural and human factors affecting water quality.

Findings: Samples of bed sediment and fish tissue have been analyzed for organochlorine compounds and trace elements. Interpretation is ongoing and a U.S. Geological Survey open-file report will be published in the year 2000.

Project title:	**Estimation of Soil Water Status in Yellowstone Grassland**
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Objective: Much of the north-central United States, including the Greater Yellowstone region, is classified as semi-arid. Limited regional water storage capacity and groundwater supply coupled with highly variable annual precipitation make water the region's primary concern. During periods of prolonged drought, vegetation is subjected to water stress that affects the photosynthetic capacity of plant tissues and thus, the abundance and quality of available forage in grasslands (for example). Public and private land managers interested in rapid assessment of large areas for vegetative quality and quantity find that these are difficult to monitor because of natural variability and the large size of areas monitored. This research was directed towards providing quantitative estimates of available soil water status derived from combined remotely sensed and ground data. High resolution remotely sensed predictions of soil water availability across management regions would be useful for estimating the spatial extent of drought and to help quantify available forage. The work would be valuable to land resource managers, as well as having value to the global change research community by providing ground-truth measurements of soil and plant water status. In order to understand how soil water and vegetative water-deficit can be monitored remotely over large land areas, our research proposed to analyze the spectral responses of vegetation to physical changes in leaf structure and function across a natural gradient in soil water status. We hypothesized that: 1) plant responses to soil water gradients can be observed spectrally and can be correlated to soil water status; and that 2) soil water gradients would be evidenced by changes in leaf spectral responses such as chlorophyll content. In order to identify the spectral region(s) where leaf structure and function response to moisture can be detected, we proposed to relate hyper-spectral (many contiguous spectral bands) image responses to soil water status and leaf physiological responses.

Findings: On August 5 and 6, 1999, we had a small field crew in the Lamar River valley between the confluences of Cache and Soda Butte creeks during the scheduled time of the Probe-1 overflights. Multiple field measurements were collected across the several hectare area at the time of the hyperspectral overflight. Measurements included: 1) soil water content using time domain reflectometry (TDR); 2) a Minolta SPAD meter for measuring leaf chlorophyll content; and 3) a GPS unit for precise positioning of sample measurements. High resolution ($1m^2$) hyperspectral remote sensing imagery was collected from the Probe-1 sensor flown on a NASA-modified aircraft within Yellowstone National Park in the areas of Cache Creek, Soda Butte Creek, and parts of the Lamar River Valley as part of the extensive Yellowstone Ecosystem Studies EOCAP project. Unfortunately, failure of the on-board gyro-stabilized mount and GPS collection unit on the days we collected our field samples resulted in imagery that could not be geometrically corrected. Since positional accuracy was essential for locating our study plots, the hyperspectral data collected on these dates were insufficient. Subsequent flights later in

August and September failed to cover our research area and, as a result, useful hyperspectral measurements were not acquired for our analyses.